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HARVEST ADVICE FOR EASTERN AND WESTERN HUDSON BAY BELUGA (*DELPHINAPTERUS LEUCAS*)

Beluga Whales. Photo by V. Lesage (DFO)

Figure 1. Map of beluga distribution in Hudson Bay and Hudson Strait. Nunavut and Nunavik (Quebec) communities and place names mentioned in the text are shown.

Context

Beluga whales (Delphinapterus leucas) are found in summer along the coasts of Hudson Bay, James Bay and Ungava Bay (Figure 1). At least four summer stocks of beluga have been identified in this region that have different migratory patterns. The eastern Hudson Bay (EHB) and western Hudson Bay (WHB) stocks are thought to overwinter in Hudson Strait and the Labrador Sea, and migrate together through Hudson Strait into Hudson Bay for the summer. The Ungava Bay (UB) stock has a shorter migratory pathway between an overwinter area that is shared with the Hudson Bay stocks and summer use of Ungava Bay. A separate, "non-migratory" population of belugas is found in James Bay (JB). These animals appear to overwinter in an area of loose ice where James and Hudson bays meet. In 2004, the Committee on the status of Endangered Wildlife in Canada (COSEWIC) recommended that the WHB stock be listed as Special Concern, and that both the EHB and UB stocks be listed as Endangered. The James Bay population has not been reviewed by COSEWIC.

Inuit subsistence harvests of beluga occur along the eastern, western and northern coasts of Hudson Bay, around the Belcher Islands, along Hudson Strait and some eastern Hudson Bay communities. There are currently no restrictions on subsistence harvesting of WHB beluga. Harvesting by hunters from the Nunavut village of Sanikiluaq, Belcher islands, is limited by a local agreement to not harvest between July 15 and September 30, the period when EHB beluga are most likely to be present.

Harvesting in Nunavik has been regulated through a combination of area closures, and seasonal and regional allowable takes. Harvesting of EHB beluga in Nunavik communities is currently managed under a 3-year management plan developed by the Nunavik Marine Region Wildlife Board in 2014, which expires January 31, 2017. The marine mammal regulations also close certain areas in UB and EHB to harvesting.

In August 2015, DFO conducted aerial surveys of beluga in WHB and EHB. DFO resource managers have

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requested Science advice on the abundance estimates and sustainable harvest recommendations for WHB and EHB beluga.

Specifically:

1. *Review the 2015 aerial survey methods and results for WHB, EHB, JB and UB beluga and estimate the stock abundance.*
2. *Determine sustainable harvest levels for WHB beluga.*
3. *Review the population model for EHB beluga and provide advice on sustainable harvest frameworks.*
4. *If appropriate and feasible, review population modelling results incorporating EHB and WHB beluga survey data.*

SUMMARY

- Aerial surveys designed to estimate beluga abundance in Hudson, James and Ungava bays were conducted during August 2015. Surveys were completed of belugas in high concentration areas around the Nelson, Churchill and Seal River estuaries on the western side of Hudson Bay, in James Bay, and eastern Hudson Bay. Owing to inclement weather, surveys did not cover northwest Hudson Bay, the Ontario coast and Ungava Bay.
- Although UB was not surveyed, no belugas were detected during systematic surveys flown in 1985, 1993, 2001 and 2008. This indicates that there is a strong probability that the stock numbers less than 100 individuals.
- Aerial survey estimates of abundance, accounting for submerged animals, were 54,500, 10,600 and 3,800 (rounded to the nearest 100) for the western Hudson Bay, James Bay and eastern Hudson Bay respectively.
- Genetic analyses have shown that the proportion of Eastern Hudson Bay (EHB) beluga in the harvest of hunters from Nunavik and the Nunavut community of Sanikiluaq varies spatially and seasonally.
- After correcting for struck and loss, annual reported harvests of 88, 68 and 43 EHB type belugas will have a probability of the stock size increasing by 25%, 50% and 75%, respectively, over the next 10 years.
- A precautionary approach framework was developed that accounts for the amount of data available for a particular stock. Criteria were identified that could be used to evaluate which approach could be applied to different stocks. For stocks where there is considerable information (Data Rich), two approaches that identified management objectives and reference levels were identified. For these frameworks, the probability of different harvest levels attaining the management objectives can be expressed explicitly.
- For stocks where less information was available (Data Poor), the Potential Biological Removal (PBR) approach was applied. Criteria for identifying the recovery factor to be used in the PBR equation were also developed.
- Information on the EHB stock allows it to be managed using the Data Rich frameworks and was considered to lie in the Cautious zone.
- One PA framework is based on the DFO- Maximum Sustainable Yield (MSY) framework and sets the Precautionary and Limit Reference Levels at 48% and 24% of K, a proxy for the maximum stock size that the ecosystem is able to support. Harvests between 26 and 61 EHB belugas would allow the stock to increase to the Healthy zone (i.e. recover above 4000

EHB belugas), within two generations (50 years) with probabilities of 80% and 50% respectively.

- The second PA framework, based on the DFO-Atlantic Seal Management framework, sets the Precautionary and Limit Reference Levels at 70% and 30% of the largest stock size observed or estimated. Harvests of 17 and 50 EHB belugas would allow the stock to increase to the Healthy zone (i.e. recover above 4700 EHB belugas) within two generations (50 years) with probabilities of 80% and 50% respectively.
- WHB belugas are abundant, but are considered to be Data Poor and therefore, the Potential Biological Removal (PBR) approach should be used to estimate a Total Allowable Harvest (TAH).
- Using a Recovery Factor of 0.75, (ed upon Recovery Factor criteria reviewed during the assessment), the PBR estimate for WHB belugas would be 753 animals. Current reported harvests of WHB animals are at 495 belugas from the Nunavut and Nunavik hunts. If a Struck and Loss rate of 1.18% was assumed, then total removals are on the order of 584 animals, which is below the PBR level.

BACKGROUND

Species Biology

Beluga whales have a circumpolar distribution. They are medium-sized toothed whales with regional variation in growth, but can reach an adult length of 400 cm and weigh up to 1000 kg. Mating is thought to occur during winter or early spring. Calves are born after a 14 month gestation and lactation lasts roughly 18 months. Beluga calves spend 2-3 years with their mother during which time they perform several seasonal migrations. It has been suggested that this extended parent-offspring association could provide the opportunity for learning migration routes. The calving interval is 3 years. At birth, the calves are brown or dark bluish in colour. The skin becomes lighter in colour as they mature, gradually turning to grey and then to white. Sexual maturity is thought to occur between 8 and 14 years of age, and longevity may be 60+ years.

Across their entire range, beluga whales are known to visit estuaries and river mouths during summer. Satellite telemetry data from the Little Whale and Nastapoka rivers in EHB and Seal, Churchill, and Nelson river estuaries in WHB show that beluga undertake regular trips between the coast and offshore areas over the course of the summer.

The Harvest

Eastern Hudson Bay belugas (EHB)

Commercial harvests in the 19th century initiated the depletion of beluga stocks in eastern Hudson Bay and Ungava Bay. Subsequent subsistence harvests may have limited the opportunity for stocks to recover. In the 1980's, limits were placed on harvesting through a combination of Total Allowable Takes (TAT) and regional closures, including the creation of a permanent sanctuary in southern Ungava Bay and seasonal closures at the Nastapoka and Little Whale rivers. Harvesting in EHB was closed from 2001 to 2006, and the Nastapoka and Little Whale River estuaries have remained closed since harvesting resumed in EHB in 2007.

Harvest statistics are available for the years 1974-2016. These statistics represent minimum estimates only, since not all villages provided catch data in all years, and information on the

number of animals struck and lost is incomplete. During 1974–2016, an average take of 119 (SE=14, N=43) EHB whales per year was reported by Nunavik communities. During the recent management plan, the average harvest was 60 (SE=17, N=17) EHB belugas over the last three years (Figure 2).

Western Hudson Bay belugas (WHB)

Harvest statistics are available for the years 1977-2015. These statistics represent minimum estimates only, since not all villages provided catch data in all years, and information on the number of animals struck and lost is incomplete. There is no management plan in Nunavut for belugas, but the hamlet of Sanikiluaq has established a summer closure to hunting of belugas that runs from 15 July to 15 September. During 1977–2015, an average of 408 (SE=16, N=39) WHB whales were reported harvested annually by the Nunavut and Nunavik communities in Hudson Bay, Hudson Strait, south Baffin Island and Ungava Bay (Figure 2)

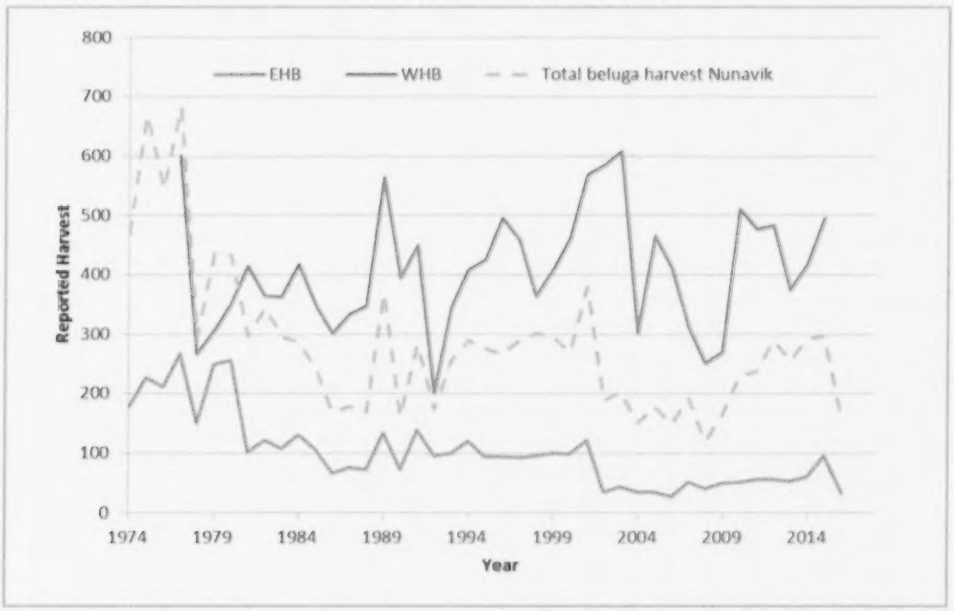

Figure 2. Total reported harvest of Western Hudson Bay (WHB) belugas by communities in Nunavut and Nunavik; total reported beluga harvest by hunters in Nunavik; and total reported harvest of Eastern Hudson Bay (EHB) belugas by hunters from Nunavut and Nunavik. Annual harvest statistics for WHB belugas from Nunavut are not available prior to 1977.

ASSESSMENT

Stock structure

Most belugas in Hudson Bay and Hudson Strait belong to the same breeding population. Animals disperse to EHB and WHB during a spring migration, then in the fall return to overwinter in Hudson Strait. They are grouped into different stocks, based primarily on their summer distribution. The EHB stock occupies an area bounded in the east by the eastern Hudson Bay arc. In the north, by the northern part of the EHB arc, just to the north of the village of Inukjuak (approximately 59° 03' N and in the south by an east-west line running approximately midway between the village of Kuujjuarapik and the top of Long Island, at the

entrance to James Bay.(55° 11' N). In an east-west direction, the EHB stock includes an area running from the EHB coast westwards to 60 km west of the Belcher Islands (81° W longitude)(Figure 1). Beluga summering along the western Hudson Bay belong to the WHB stock. The distribution of these animals is centered on the Nelson, Churchill and Seal river estuaries. Beluga are seen north along the Nunavut coast, and south along the Ontario coast, but more work is needed to confirm if animals in these extended areas form part of the WHB stock or separate stocks. Because of this uncertainty in stock structure, certain analyses examine only whether belugas belong to the EHB stock or other stocks, which are referred to as Not_EHB belugas. Beluga in James Bay, lying south of 55° 11' N belong to the James Bay summer stock. The genetic evidence supporting the concept that EHB beluga form a separate stock, from beluga in James Bay and western Hudson Bay has been based on samples obtained from hunters along the EHB coast, primarily near the Little Whale and Nastapoka Rivers. Satellite transmitters deployed on animals in EHB, WHB and James Bay have confirmed that animals remain within their respective ranges throughout the summer. Additional evidence from nuclear genetic markers suggests that belugas in the adjacent James Bay area form a distinct breeding population. The absence of movement of animals from James Bay into the eastern Hudson Bay arc supports this.

Biological Samples

A tissue sampling program in Nunavik was initiated in the early 1980s, but has only been operating on a regular basis since the mid-1990s. Hunters from all Nunavik communities provide a tooth, skin samples and information on where animals are harvested. Participation rates vary, but samples are generally obtained from around 30% of the reported catch. There is a slight overrepresentation of male (vs female) beluga in the harvest, but there have been no significant trends in the sex ratio of the harvest since 1984. The mean age of belugas in the catch (1984-2015) was 18.5 and 23.6 years old for EHB_{type} and Not_EHB_{type} belugas, respectively. No significant trend was observed in the mean age of the harvest over time.

Genetic mixture analysis

A genetic mixture analysis of the EHB stock focused on tissue samples collected in Nunavik as well as Sanikiluaq (Nunavut), between 1982 and 2015. This analysis updates a previous study by including new samples obtained between 2014 and 2015 as well as additional data from some older samples.

Two source stocks were defined as EHB and Not_EHB. The dates and locations for each of the regional harvests were aligned with the definitions of hunting areas and seasons that have been in use since 2014 to manage the Nunavik beluga hunt; The genetic mixture analysis provided an estimate of the proportion of individuals in the harvest belonging to the EHB or Not_EHB stocks.

Areas of mixed hunts in Nunavik coastal waters that along the common EHB and WHB (also referred to as Not_EHB) seasonal migratory corridor were identified and include northeastern Hudson Bay (NEHB), southern Hudson Strait (HS), Ungava Bay (UNG) and the Sanikiluaq (SAN) area which encompasses hunting zones located around the Belcher Islands (Nunavut). For NEHB, HS and UNG, samples were divided into two hunting seasons: a "spring" hunt from February 1 to August 31, and a "fall" hunt from September 1 to January 31. Proportions in the Ungava Bay harvest in the summer (July-August) were also examined because Ungava Bay is also considered as a potentially distinct summer stock.

In Nunavik, samples from the spring harvest in Hudson Strait indicate that 8.4% and 10.8% of the whales harvested respectively in the Ungava Bay and the Hudson Strait hunting area during this season belong to the EHB stock. Their proportion in the Ungava Bay harvest declines to 3.1% in summer.

In the fall harvest, the proportion of EHB beluga in northeast Hudson Bay and the Hudson Strait are estimated at 30.2% and 26.1%respectively (Table 1).

For Sanikiluaq only, two different definitions of the spring hunt were examined, one ("Spring") bounded by the voluntary closure date in place between 2010 and 2012 (i.e., April 1 to June 30) and the other ("Extended Spring") using the post-2012 closure date (i.e., April 1 to July 14).

For beluga harvested near Sanikiluaq, EHB beluga represents 1.5% of the harvest in spring (April 1 – June 30), increasing to 4.4% if the spring period was extended to July 14. This proportion increases to 25.6% in summer. No EHB animals have been reported from the fall harvest in Sanikiluaq.

Table 1. Two source populations, an Eastern Hudson Bay (EHB) and a Not_EHB population were considered, based on genetic mixture analysis of mtDNA haplotype distribution. The proportions of beluga (%) in the harvest from the EHB source stock in the harvest of Nunavik hunt areas (upper part) and Sanikiluaq harvest (lower part), are shown. N samples: number of individual samples; N events: number of different hunting dates; 95%CI: 95% confidence interval based on variance among hunting events; CV: coefficients of variation based on individual samples / hunting events. ND: not determined (small sample size).The Unknown group comprises haplotypes that could be rare haplotypes or belong to an unknown population.

	N samples	N events	% EHB type	95% CI	% Unknown
Spring (Feb 1 - Aug 31)					
Hudson Strait	611	278	10.8	7.1 - 15.2	6.1
NE Hudson	2	1	ND	-	-
Ungava Bay	75	49	8.4	0.9 - 23	9.3
Fall (Sept 1 - Jan 31)					
Hudson Strait	352	146	26.1	19.3 - 33.6	2.8
NE Hudson	20	8	30.2	12.1 - 52.3	10.0
Ungava Bay	3	3	ND	-	ND

Sanikiluaq

Season	N samples	N events	% EHB	95% CI	% Unknown
Spring (Apr 1 - Jun 30)	297	107	1.5	0.0 - 5.7	21.2
Extended spring (Apr 1 - Jul 14)	320	120	4.4	1.1 - 9.9	20.0
Summer (Jul 1 - Aug 31)	31	18	25.6	5.2 - 55.1	12.9
Fall	42	28	0.0	-	2.4

Season	N samples	N events	% EHB	95% CI	% Unknown
(Sept 1 – Nov 30)					
Winter (December 1 - March 31)	56	7	36.6	10.5 - 68.2	32.1

Abundance estimate

Surveys designed to estimate the number of beluga present were carried out in eastern and western Hudson Bay, and James Bay during August 2015. The original design planned for aerial surveys of Ungava Bay, eastern Hudson Bay, James Bay, southwestern, western and northwestern Hudson Bay but some areas could not be covered due to poor weather.

Although Ungava Bay was not surveyed, no belugas were detected during systematic surveys flown in 1985, 1993, 2001 and 2008. This indicates that there is a strong probability that there are less than 100 individuals in this stock.

James Bay and Eastern Hudson Bay

Systematic aerial line-transect surveys to estimate abundance of beluga whales were flown in James Bay and eastern Hudson Bay (Figure 3). The survey in James Bay was completed between 29 July and 8 August while the survey of EHB was completed twice between 8 August and 3 September. A total of 324 groups of belugas or 890 individuals were detected during the survey of both regions. The estimate of animals at the surface was 5,074 belugas in James Bay and 1,746 belugas in EHB. These surface abundance estimates can be corrected for the proportion of submerged animals that cannot be detected from an aerial using a correction factor of 0.478 whales at the surface ('availability bias'). This resulted in an estimate of total abundance in James Bay of 10,615 (cv = 0.25, 95% CI: 6,559-17,178). Using the same correction for submerged animals and adding a count of 167 belugas in the Little Whale River estuary resulted in an estimated abundance in eastern Hudson Bay of 3,819 (cv = 0.43, 95% CI: 1,664-8,765) belugas (Table 2).

Table 2. Abundance estimates for the EHB and WHB beluga whale stocks. Indices have been corrected for availability bias.

Year	EHB estimate (SE)	WHB estimate (SE)
1985	4282 (557)	
1993	2729 (1092)	
1987		31,124 (6967)
2001	2924 (1404)	
2004	4274 (1581)	51,761 (15,875)
2008	2646 (1244)	
2011	3351 (1642)	
2015	3819 (1642)	54,473 (5,329)

Western Hudson Bay (WHB)

Five strata (three visual and two photographic) encompassing high use areas around three river estuaries where recurring aggregations of WHB beluga area found during the summer, were also surveyed in August 2015. The photographic surveys completely covered high-density aggregations in the Churchill River and near the mouth of the Seal River (Figure 3). Near

surface abundance estimates for each stratum were adjusted for availability bias using dive data from eight WHB belugas instrumented with satellite tags two weeks prior to the aerial survey, resulting in a correction factor of 1.24 ± 0.05 for clear water. This resulted in an estimated total abundance of 54,510 (cv = 0.098, 95% CI=44,988-65,957) (Table 2).

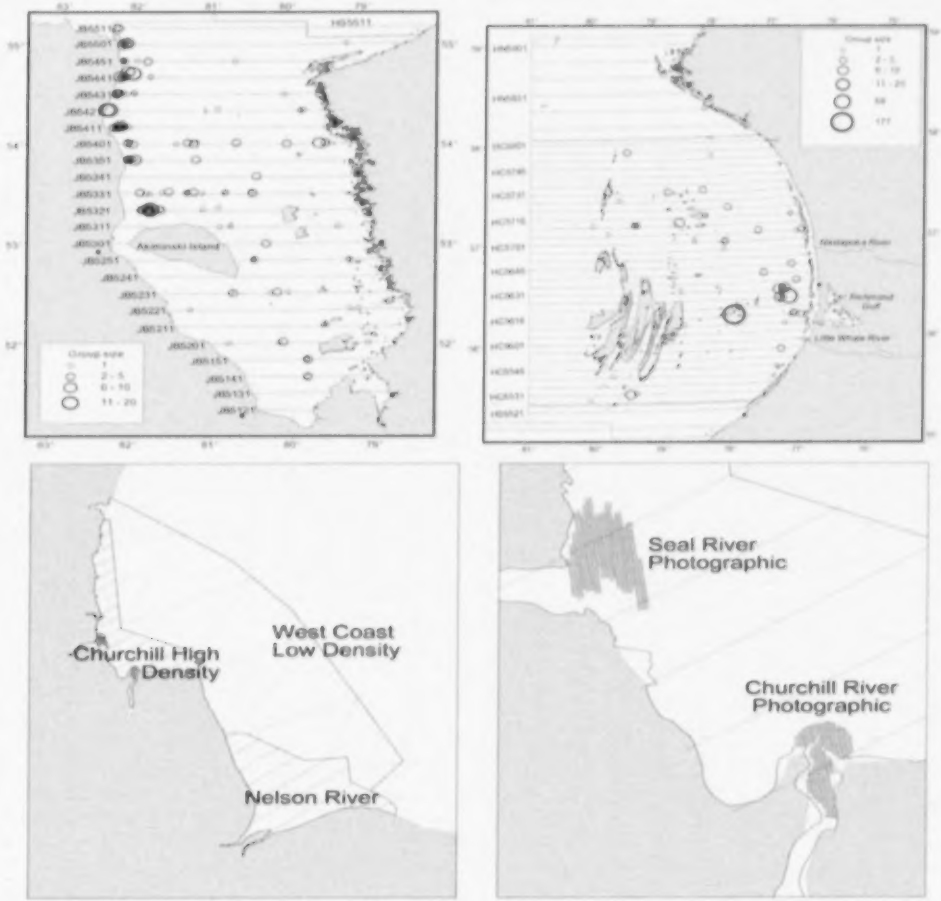

Figure 3. Transect lines flown and sightings of belugas in James Bay (top left), first survey flown in eastern Hudson Bay (top right), visual transects covered by western Hudson Bay survey (bottom left), and full coverage photographic survey areas (bottom right).

Modeling abundance of beluga in Hudson Bay and impact of harvests

A population model incorporating updated information on harvest statistics and stock composition was fitted to EHB aerial survey estimates of abundance. The population model, incorporating updated information on harvest statistics (1974-2016) and stock composition, was fitted to seven aerial survey estimates (1985-2015) from the EHB stock (Table 2). The model indicates that the population declined from 1974 reaching a minimum of 3,100 in 2001. The estimated population in 2016 is 3,400 (95% CI=2,100-5,000) (Figure 4).

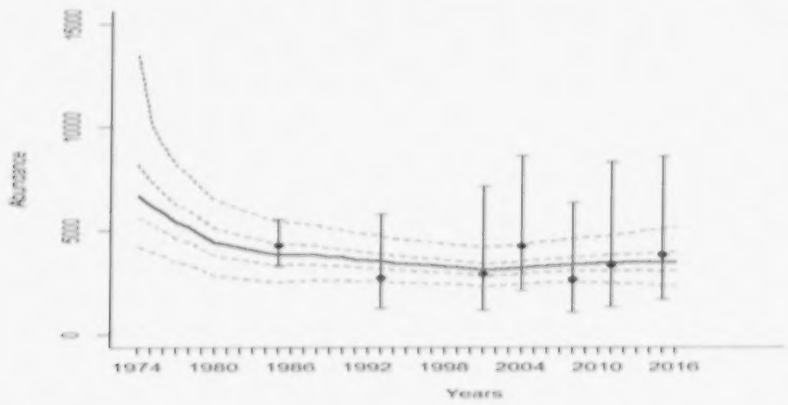

Figure 4. Model estimates of stock abundance for Eastern Hudson Bay beluga. Solid line: median estimates. Dashed lines: 25% and 75% quartiles. Dotted lines: 2.5% and 97.5% quantiles (= 95% Bayesian Credible Interval). The model took into account stock composition of harvested whales and was fitted to aerial survey estimates, corrected for animals at the surface (closed circles, ±95% Confidence intervals).

Based upon the aerial survey estimates, the WHB beluga stock is one of the largest in the world. A population model that incorporated harvest information from communities around Hudson Bay and southern Baffin Island was fitted to the three available abundance surveys in order to estimate total abundance and population trend. Different model runs indicated that the population was stable or that it was increasing. However, there is too little information at the current time to indicate which model run was most appropriate to describe dynamics of this population. Therefore, it was concluded that Total Allowable Harvest (TAH) levels should be estimated using the 2015 aerial survey estimates.

Harvest advice

Sustainable Yield (SY)

The current approach to managing EHB beluga, referred to as the Sustainable Yield (SY) is to identify catch levels that have a probability of a population decline of 50% over 10 years. Using SY, an annual landed harvest of 68 EHB belugas is estimated to have a 50% probability of a population decline (or increase), over a 10 year period (Figure 5). Harvests of 88 and 43 beluga would have 75% and 25% probabilities of a decline, respectively. These estimates for landed harvests account for Struck and Lost (S&L).

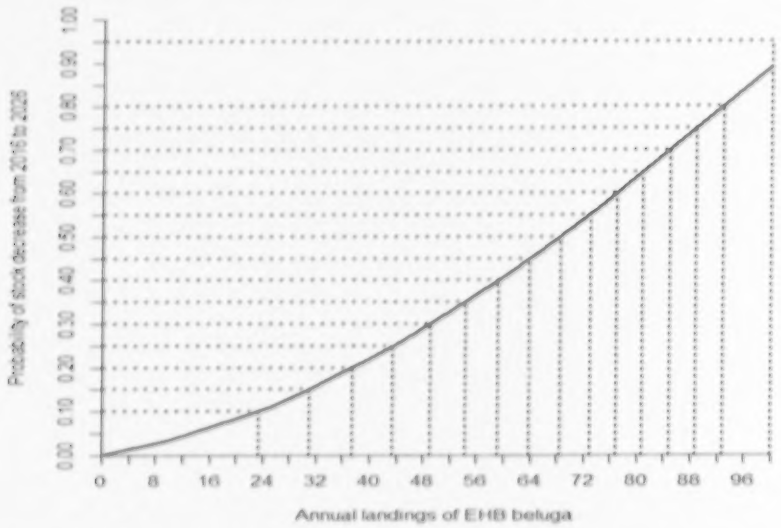

Figure 5. Probability of a population decline from current levels over 10 years at different levels of landings of EHB belugas. Probabilities are expressed as a proportion and must be multiplied by 100 to convert to a percentage probability.

The Precautionary Approach (PA)

The PA identifies decision rules for stock management when the resource reaches clearly stated reference points and aims to be more cautious when information is less certain. The Precautionary Reference Level (PRL) and Limit Reference Level (LRL) divide the management space into Healthy, Cautious and Critical zones. The management objective is to manage stocks in the Healthy zone (i.e. above PRL). If the stock is below the PRL, then catches should be limited to allow the stock to recover to the Healthy zone within one to two generations. Two forms of how to apply the PA framework were investigated:

(1) Maximum sustainable yield, and;

(2) the Atlantic Seal Management Strategy.

The method to assess sustainable harvest depends on where a stock lies along a Data Poor-Data Rich continuum. For stocks where there is a greater understanding of abundance, trends and dynamics of the population it is possible to use one of these frameworks, where the probability of respecting the management objective can be identified explicitly. For stocks with less information available concerning their dynamics, harvest levels have been set using the Potential Biological Removal (PBR) method.

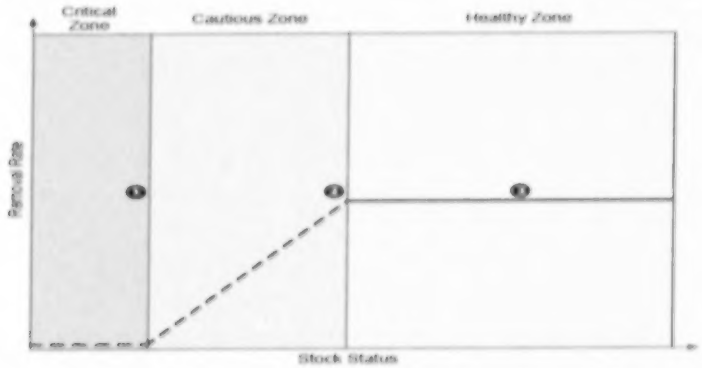

Figure 6. The generalized PA framework for fisheries. 1. The Limit reference level (LRL). 2. The precautionary reference level (PRL). 3. A removal rate identified to maintain the resource within the Healthy zone.

Guidelines were identified that could be used to evaluate whether the stock lends itself to a Data Rich or a Data Poor framework. Guidelines can include:

1. What is the certainty in stock composition/identification. Are there data to support stock delineation, stock composition of the harvest? Are harvest composition data incorporated into the model as a fixed (deterministic) value because there are no data or included as a sampling distribution (probabilistic)?
2. What time series of abundance estimates is available? For example, for Atlantic seals a criterion is three or more abundance estimates available from the last 15 years, with the last estimate ≤5 years old. Are all estimates considered 'good' or during peer review were concerns raised? Are the estimates reasonably precise (e.g. CV < 30%)? Are different methods and approaches used to assess abundance? Is the entire stock surveyed or does the survey target a portion of the stock (e.g. age group)?
3. Are there reliable harvest statistics? Are the data obtained from independent observers? Is there verification? What is the frequency of reporting (weekly, monthly, end of season)? Are data missing and if so is it frequent or rare?
4. Are there other data that could provide insights into stock dynamics or trend (e.g. levels of mortality, reproduction, trends in mean age/sex composition of the harvest)?
5. What type of population model can be fitted to the abundance data (e.g. surplus production, age-structured)? Is there a reasonable estimate of historical abundance or carrying capacity?
6. Does the model provide a reasonable fit? Does visual inspection of abundance estimates and model behavior appear reasonable?
7. Is the model robust to the assumptions that have been used?
8. Do model diagnostics suggest internal consistency with the data (e.g. are there signs of autocorrelation, convergence, cross-correlation)?

Using these guidelines, the EHB beluga stock can be considered Data Rich because of the number of surveys, model fit to the data, and robustness of the model to assumptions that have been used. Two approaches, identified as the DFO-Maximum Sustainable Yield (MSY), and

DFO Atlantic Seal Management (ASM) frameworks were examined to identify where the reference levels should be set, and the acceptable levels of risk. The DFO-MSY framework sets the Precautionary Reference Level and the Limit Reference Level at abundance estimates equal to 48% and 24% respectively of K, which is a proxy for the maximum stock size that the ecosystem is able to support. For EHB, K was estimated to be 8,000 individuals. Under the DFO-MSY approach, the PRL and LRL were set at 4,000 and 2,000 belugas, respectively. With an estimated abundance of 3,400 belugas, the stock lies within the Cautious zone (Figure 6). Harvests of 26 to 61 animals would have a probability of 80% and 50 % respectively of allowing the population to recover above the PRL within 50 years (Figure 7).

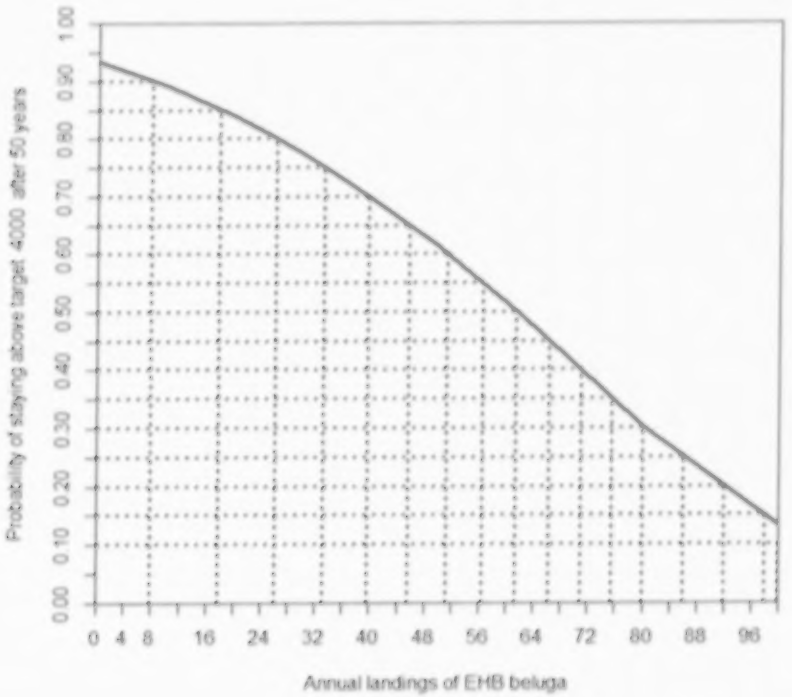

Figure 7. DFO-MSY framework. Probability that the population will be above the Precautionary Reference Level of 4,000 animals in 50 years for different EHB beluga harvest levels. Probabilities are expressed as a proportion and must be multiplied by 100 to convert to a percentage probability.

The DFO-ASM approach avoids the difficulties of identifying an appropriate K by identifying the largest stock size observed or estimated (N_{max}), and then sets the PRL and LRL at 70% (N_{70}) and 30% (N_{30}) respectively of N_{max}. N_{max} is estimated to be 6,600 beluga in the EHB stock. Under the DFO-ASM approach, the PRL and LRL would be set at 4600 and 2000 animals respectively. With an estimated abundance of 3,400 belugas, the stock lies within the Cautious zone. Allowable catches would be slightly lower using the DFO-ASM approach compared to the DFO-MSY approach to have the same probability of recovering into the Healthy zone; catches of 17 and 50 animals would have a probability of 80% and 50% respectively of allowing the population to recover above PRL (Figure 8) within two generations or 50 years.

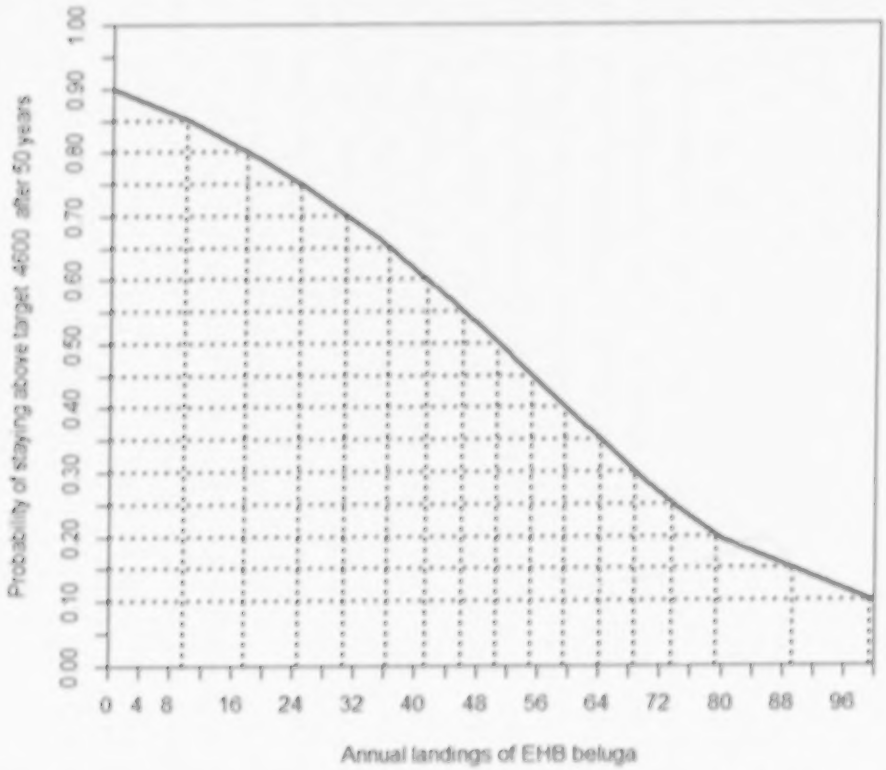

Figure 8. DFO-ASM framework. The probability that the population will be above the PRL of 4,700 animals) after 10 years for different levels of harvest of EHB beluga. Probabilities are expressed as a proportion and must be multiplied by 100 to convert to a percentage probability.

For the WHB stock, it was concluded that there was not enough information available at this time, based on the criteria outlined above, to fit a population model that describes the population dynamics. Instead, the Total Allowable Landed Catch (TALC) was estimated using the 2015 aerial survey estimate of abundance and the Potential Biological Removal (PBR) method:

$$PBR = 0.5 \times R_{max} \times F_R \times N_{min}$$

where R_{max} is the maximum rate of population increase, with a default value for cetaceans of 0.04, F_R is a recovery factor (between 0.1 and 1), and N_{min} is the estimated population size using the 20-percentile of the lognormal distribution (Wade 1998). The F_R that is applied depends on our understanding of stock status (Table 4).

The WHB stock is abundant, but there only three survey estimates of abundance of this stock since the mid-1980s. An appropriate F_R would be 0.75. Based on a 2015 survey estimate of 54,473 (CV=0.098), N_{min} was 50,203, resulting in PBR=753, for recovery factor of 0.75. Using the PBR approach, a Total Allowable Landed Catch (TALC) is estimated as TALC=PBR-(all sources of human related mortality), which includes animals Struck and Lost (SL). The current reported harvest in 2015, the last year for which harvest statistics are available is 495 WHB belugas. Applying a Nunavut specific SL rate of 1.18 for beluga (DFO 2008), the current harvest is on the order 584 belugas, which is below the PBR estimate of 753 belugas with a F_R of 0.75.

Table 4. Proposed guidelines for application of various levels of recovery factors (R_F) for use in Canada.

	Population trend	Examples	Justification
1	Abundant, increasing or stable	Beaufort Sea beluga	Abundant, infrequent surveys, other demographic data available
0.75	Abundant, data limited	WHB beluga	Abundant, survey effort limited
0.5	Abundant, declining or unknown	High Arctic beluga	Abundant, limited data
0.25	Small, increasing or stable	EHB beluga	Small, appears stable
0.1	Small , declining or unknown	St Lawrence Estuary beluga	Small, appears declining or unknown

Sources of Uncertainty

The stock designations for beluga in the Hudson/James Bay areas are based on the summer distributions of animals. Different analyses have supported the summer stock hypothesis. The EHB stock has been characterized genetically by the mitochondrial haplotype frequency of samples obtained from hunters primarily near the Little Whale and Nastapoka River. It is assumed that animals seen during the summer surveys of the offshore EHB areas have the same genetic composition as animals sampled from the two coastal EHB rivers. If the genetic composition of animals seen in these offshore areas is not the same, then we may be underestimating the impact of the harvest on the EHB stock. Additional research should attempt to improve our understanding of the genetics and movements of animals summering in the EHB arc area, particularly those seen in the offshore areas.

Aerial survey estimates of animals at the surface are adjusted for animals that are diving. The EHB and James Bay estimates are adjusted using correction factors from the St Lawrence River estuary where the estimate of the proportion of animals at the surface is 0.478. These factors have been applied to the entire time series of aerial survey estimates, but ideally adjustment factors should be applied based on telemetry studies from the EHB area in the year that surveys are flown, since these factors may vary between regions and across years.

There is a lack of data on vital rates of beluga, which limits opportunities to model the dynamics of this stock. Field observations of animals struck and killed, but not recovered, would help to reduce the uncertainty associated with this parameter. Precise information on age structure of the stock and composition of the harvest in WHB is lacking. All of these add uncertainty in our estimates.

CONCLUSIONS AND ADVICE

The EHB stock of belugas is stable, with a current estimate of 3,400 animals. Harvest levels in the past were set to maintain a 50% probability of no population decline over a 10 year period. This approach does not allow for rebuilding of the stock and does include any buffer to accommodate uncertainty in assessment estimates, unusual mortality events, or environmental variability. The PA management frameworks described in this document have been developed internally. Management objectives and risk tolerance are guided by processes that include respective management authorities and consultations with rights holders. Consultation with co-

management partners and representative aboriginal organizations is required before it would be possible to adopt and implement any new management frameworks to replace existing ones.

A PA framework was developed for the EHB stock. This framework indicates that the stock is currently in the 'Cautious' zone. Reported harvests need to be reduced to within a range of 17-61 EHB belugas, depending on the probability of recovery and management framework adopted, for the stock to recover to the Healthy zone within 2 generations, which is approximately 50 years.

The WHB beluga stock currently estimated to be 54,500 animals. The PBR method was used to estimate the TALC. The PBR was 753 belugas using a recovery factor of 0.75. The current reported harvest from the WHB stock in 2015, the last year for which harvest statistics are available, is 495 WHB belugas. Adjusting the 2015 reported harvest for animals Struck and Lost, was on the order 584 belugas, which is below the PBR estimate.

OTHER CONSIDERATIONS

Belugas often travel in groups. Clustering of harvests in a given year may increase the risk of removing entire family units, which could affect genetic diversity as well as the transfer of knowledge of migration routes to future generations. This transmission of information is hypothesized to be the mechanism for site fidelity. The WHB survey was limited in spatial coverage due to poor weather. Belugas are also seen along the Ontario coast and in northern Hudson Bay. Additional work is needed to improve our understanding of stock relationships among animals in these areas. If they do form a single stock, then we have underestimated WHB stock abundance.

SOURCES OF INFORMATION

This Science Advisory Report is from the October 17-21 2016 on Eastern and Western Hudson Bay Beluga - 2015 Aerial Survey Abundance Estimates and Sustainable Harvest Advice. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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ᐃᒪᖅᑕᑕᓚᐅᔪᓂᖅ. 2018. ᖃᓄᐃᓕᒐᓴᐅᓂ ᐅᓄᖅᓯᕐᓂᓄᓂ ᐅᖃᐅᓯᐅᕐᓂᖅᐸᒃᓂ ᑲᓇᑕᓂᒃ ᐱᖓᓱᓇᓂᒃ ᐊᖏᓂᓇᓂᒃ ᑕᓯᐅᔨᓕᕐᓂᒃ ᖃᓄᐃᓕᒐᓴᐅᓂᒃ (Delphinapterus leucas). ᐃᒪᖅᑕᑕᓚᐅᔪᓂᖅ ᑲᓇᑕᒥ ᑭᓚᓯᔪᐊᖅᑎᓂᒃ ᐅᖃᐅᓯᐅᕐᓂᖅᐸᒃᓂ ᐅᖃᐅᓯᐅᕐᓂᖅᐸᒃᓂ ᑎᑎᕋᖅᑕᓂᒃ ᐅᖃᐅᓯᐅᕐᓂᖅᐸᒃᓂ ᑭᓚᓯᔪᐊᖅᑎᓂᒃ ᑭᓚᓐᓇᖅᑐᖅᑎᓂᒃ 2018/008